Unmanned Aircraft Systems Sensors

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OUSD(AT&L)/Defense Systems
Air Warfare

Report Documentation Page

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Outline

- Background
  - UA in Operation IRAQI FREEDOM
    - Small UA
    - Tactical UA
    - Operational
    - Theater UA
- Electro-optical and Infrared Sensors
  - Small UA
  - Tactical UA
  - Operational & Theater UA
- Radar Sensors
  - Small UA
  - Tactical UA
  - Operational & Theater UA
- Sensor Fusion
- Summary

Small UA in Operation IRAQI FREEDOM

	User / Mission	Size		Payload	Endurance
	Army, Air Force & SOCOM				
		Weight	4 lbs		
	Over the Hill	**Length**	3 ft		
	Reconnaissance	**Wing Span**	4.4 ft		
		Payload Weight	1 lb	EO or IR	80 min
Raven					
	Marine Corps	**Weight**	4 lbs		
		Length	2.4 ft		
	Over the Hill	**Wing Span**	3.75 ft		
	Reconnaissance	**Payload Weight**	1 lb	EO or IR	40-60 min
Dragon Eye					
	Air Force	**Weight**	4.5 lbs		
		Length	3 ft		
		Wing Span	4 ft		
	Force Protection	**Payload Weight**	1 lb	EO or IR	60-90 min
FPASS					
	SOCOM	**Weight**	8 lbs		
		Length	6 ft		
		Wing Span	9 ft		
	Special Operations	**Payload Weight**	2 lbs	EO or IR	60 min
Pointer					
	SOCOM/USMC	**Weight**	14 lbs		
		Length	4.2 ft		
		Wing Span	7.7ft		
	Special Operations	**Payload Weight**	4 lbs	EO or IR	3-5 hr
Silver Fox					
	USMC	**Weight**	40 lbs		
		Length	4 ft		
		Wing Span	10 ft		
	Force Protection	**Payload Weight**	6 lbs	EO or IR	15 hr
Scan Eagle					

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Tactical UA in Operation IRAQI FREEDOM

	Army	**Weight**	327 lb	EO/IR	5 hrs
		Length	11.2 ft		
	Brigade Level	**Wing Span**	12.8 ft		
	Recce	**Payload Weight**	60 lbs		
Shadow (RQ-7)					
	Marine Corps	**Weight**	452 lbs	EO/IR	5 hrs
		Length	14 ft		
	Suveillance/Recce	**Wing Span**	17 ft		
		Payload Weight	75 lbs		
Pioneer (RQ-2B)					
	Army	**Weight**	1600 lbs	EO/IR	11.6 hrs
		Length	23 ft		
	Division/Corps Level	**Wing Span**	29.2 ft		
	Recce	**Payload Weight**	200 lbs		
Hunter (RQ-5)					

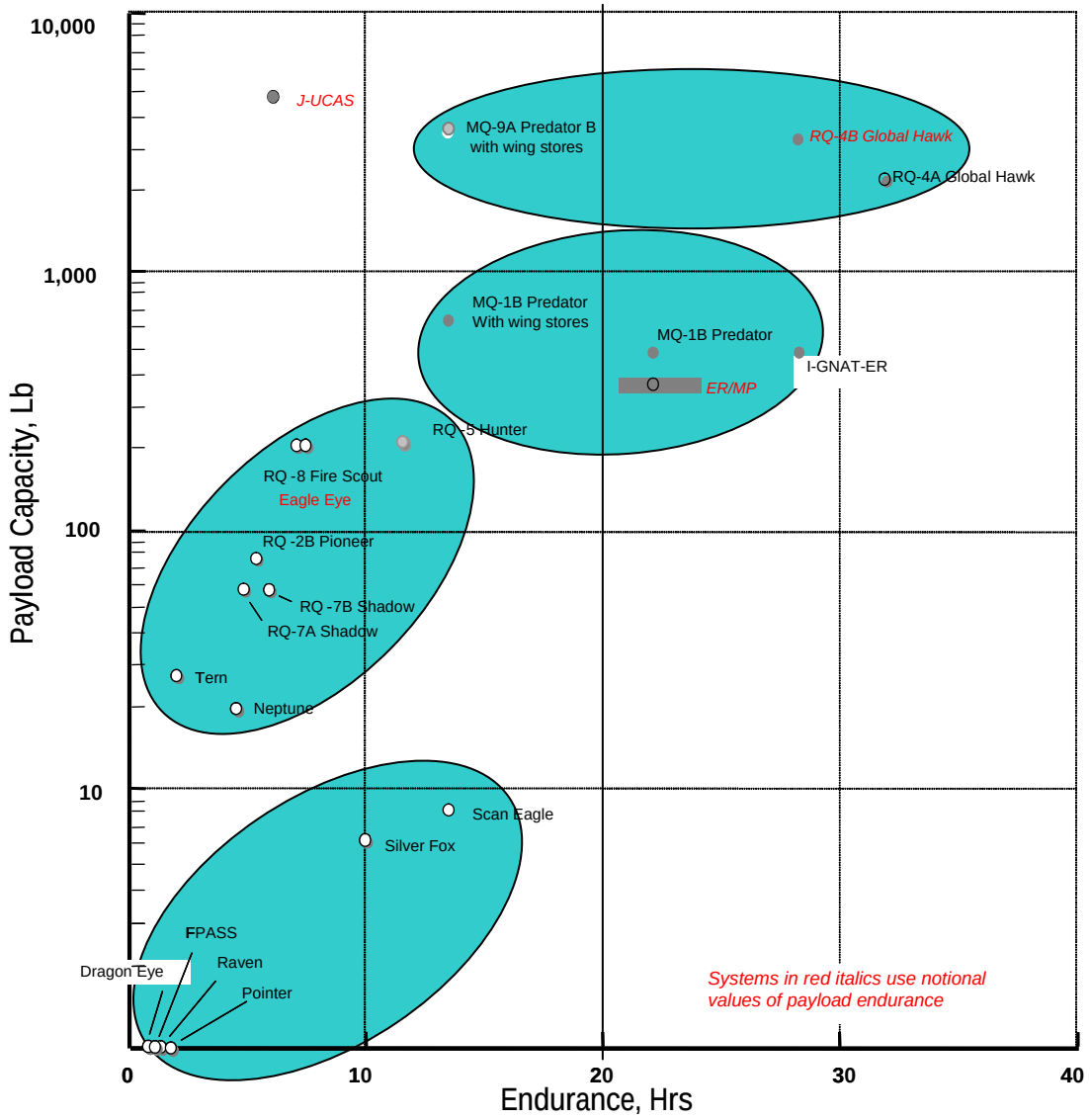
Operational UA in Operation IRAQI FREEDOM

		User / Mission	Size		Payload	Endurance
		Air Force	**Weight**	2250 lbs		24 hrs
			Length	28.7 ft		
		Armed Recce	**Wing Span**	49 ft		
			Payload Weight	**Internal:** 450 lbs	EO/IR & SAR	
				Wings: 100 lbs each	Hellfire	
Predator (MQ-1)						
		Army				
			Weight	2250 lbs		24+ hrs
		Division/Corps Level	**Length**	27 ft		
		Recce	**Wing Span**	49 ft		
			Payload Weight	450 lbs	EO/IR & SAR	
I-Gnat						

Prototype Theater UA in Operation IRAQI FREEDOM

		Service / Mission	Size		Payload	Endurance
		Air Force	**Weight**	10,000 lbs		
			Length	36.2 ft		
		Armed Recce	**Wing Span**	64 ft		
			Payload Weight	**Internal:** 750 lbs	EO/IR & SAR	24+
Predator B (MQ-9)				**Each Wing:**	GBU-12	
Prototype				Inboard: 1500 lbs		
				Middle: 350 lbs		
				Outboard: 150 lbs		
				Maximum: 3750 lbs		
		Air Force	**Weight**	26,700 lbs		
			Length	44.4 ft		
		Persistent High	**Wing Span**	116.2 ft		
		Altitude Surveillance	**Payload Weight**	1950 lbs	EO/IR & SAR	24+
Global Hawk (RQ-4A)		& Reconnaissance				
Prototype						

UA Payload Weight vs. Endurance



UA Sensor Summary

- All UA have an Electro-Optic (EO) and Infrared (IR) capability
- Small UA sensors
  - EO/IR is primary sensor
  - Fixed vs Gimbaled
- Tactical UA sensors (in order of priority)
  - EO/IR
  - SIGINT
  - Radar
  - Comm relay
- Operational & Theater UA sensors (in order of priority)
  - EO/IR
  - Radar
  - SIGINT
  - Comm relay
- Sensor specifications drive UAS costs and capabilities
  - Cost control is critical to development of UAS and UA sensor capabilities

Small UA EO/IR Sensors

- **EO** – Requirement for a facial recognition capability while remaining undetected (NIIRS 8+)
- **IR** – Requirement for identification and tracking while remaining undetected
- **Small UA (SUA)**
  - ***SUA*** are ***expendable*** and ***numerous***
  - Sensors must be
    - Reliable
    - Low Cost
    - Supportable
    - Commercially available
- **Goal for Industry**
  - Gimbaled sensor with EDTV capability (480P)

Raven

System Components:

- 3 Air Vehicles (AV) per system
- 3 Payloads
- One (1) Ground Control Unit
- Remote Video Terminal (RVT)
- Batteries: Mission & Rechargeable
- Carry / Protective Cases
- Battery Charger / Power Supply
- Field Maintenance Kit
- Spares and Repair Parts

Mission:

Army tactical level reconnaissance, surveillance, target acquisition, and battle damage assessment

Capabilities:

- Hand Launched / AutoLand Recovery
- Military P(y)-Code GPS
- AutoNavigation
- Quick Assembly (< 3 min)
- Man Portable / Backpackable
- Quiet
- Reusable (100+ flights)
- Typical Operational Altitude 150-500 ft AGL
- Climb to Operational Altitude in 1-2 mins

Characteristics / Description:

Power:	Batteries – Mission: Lithium (LiSO2) – Rechargeable: Lithium Ion
Wing Span:	4.5 feet
Weight:	4 lbs (w/carrying case, 12 lbs)
GCU Weight:	17 lbs
Range:	8-12 km
Endurance (Mins):	90 (Lithium) / 60 (Lithium Ion)
Speed:	27-60 mph, Cruise 40 mph
Payload(s):	High Resolution, Day / Night Camera & Thermal Imager
Crew / Manpower:	2 Soldiers

Raven Image – OEF

"Altitude Hold" Mode (Commanded Altitude)

DTG

GPS Satellites

Aircraft MH Battery Voltage Reading

AGL Altitude Range from GCU

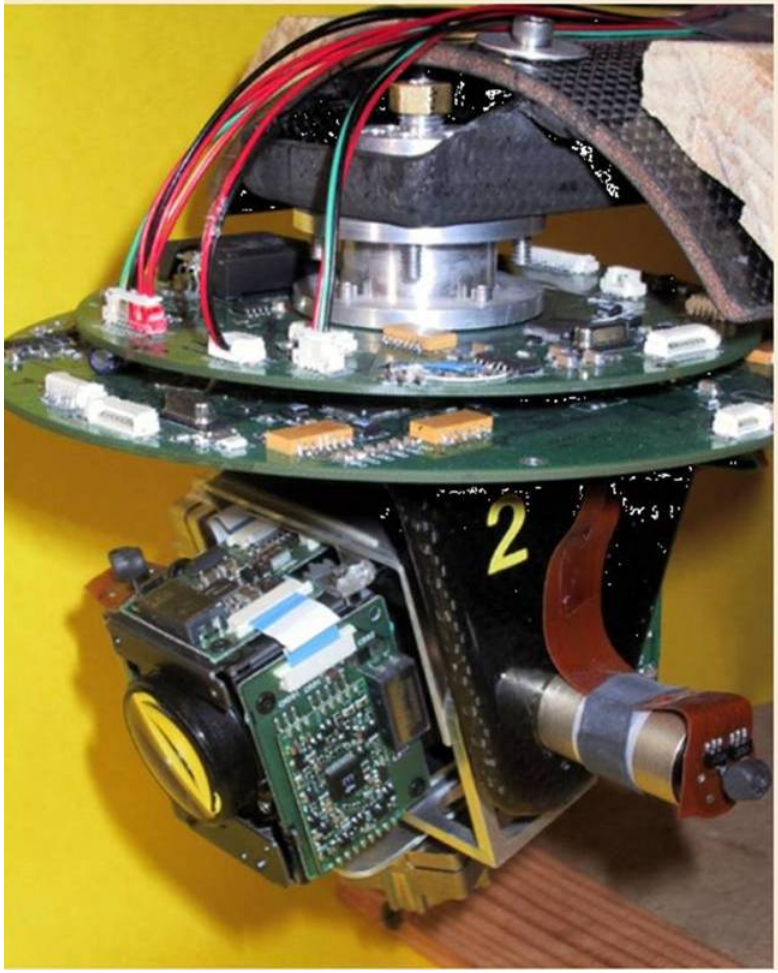
Raven video and image capture from food distribution convoy mission.

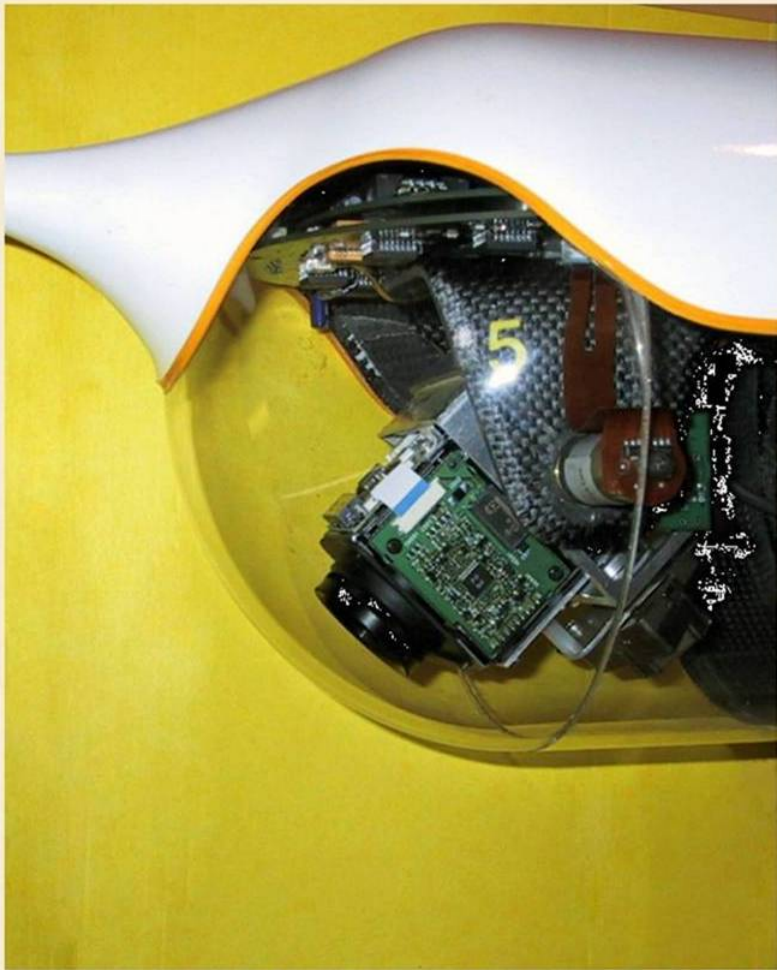
ScanEagle

Wing span	10.0 ft
Fuselage diameter	7.0 inches
Overall length	4.0 ft
Folded length	6.5 ft
Folded width	1.5 ft
Folded height	1.3 ft
Max. Gross Wt.	40.0 lbs

- **Max level speed** — **68 knots**
- **Cruise spd @ max wt.** — **48 knots**
- **Loiter spd @ max wt.** — **42 knots**
- **Service ceiling @ max wt.** — **16,000 ft**
- **Endurance, no reserves** — **Current : 15+ hrs**
  Planned:
  B: 30+ hrs
  C: 40+ hrs
- **Launch** — **Pneumatic catapult**
- **Recovery** — **"Skyhook" wingtip snag/ land in 600 x 100 ft field or skid landing**
- **Navigation** — **D-GPS**
- **Surveillance** — **25:1 zoom daylight color video camera (or IR) in inertially stabilized nose turret**

Stabilized EO Turret System





Stabilized Camera System

Full Motion Video Camera System Stabilized on Mobile Flight Test Center at Wide Angle FoV at 2000’.

Video Camera System Stabilized on Mobile Flight Test Center and Zoomed to 11:1 at 2000’.

Tactical UA EO/IR Sensors

- EO – Requirement for a facial recognition capability while remaining undetected. (NIIRS 8+)
- IR – Requirement for identification and tracking while remaining undetected
- Laser Designator Range Finder – Requirement for integration with EO/IR sensor
- Tactical UA (TUA)
  - ***TUA*** are ***attritable,*** fewer in number than SUA
  - Sensors must be
    - Gimbaled turret providing weapons quality precise coordinates
    - Reliable
    - Supportable
    - Commercially available
- Goal for Industry
  - Gimbaled sensor with HDTV capability (720P)
  - Challenge is low cost gimbaled turret
  - Ability to upgrade easily (FPA)

Shadow RQ-7B

Characteristics / Description:

Wing Span	14 feet
Weight	380 lbs
Range	~ 125 km
Airspeed	(60 kt loiter, 105 kt dash)
Altitude	14,000 Ft
Endurance	> 5 Hours @ 50 km
Primary Payload (s)	EO / IR (up to 60 lb)
Launch / Recovery	100m x 50m Area

Capabilities :

- Automatic Landing and Takeoff
- System and Maintenance Section transportable on 3 C-130s
- Early entry capability with 1 C-130
- Compatible with ABCS
- EO / IR Sensor
- TCDL Ready

Unit Composition

- Platoon Set = a System:
  - 22 Soldiers (2 Officers, 20 Enlisted)
  - 4 - Air Vehicles
  - 6 - HMMWVs (Ground Control Station, air vehicle transport, troop transports, maintenance shelter)
  - 3 - Trailers (equipment, launcher)
  - 4 - Remote Video Terminals

POP 300 Sensor Characteristics

Detector	640 x 480 InSb
Narrow Field-of-View	2.3 x 1.7 Deg
Medium Field-of-View	9.2 x 6.9 Deg
Wide Field-of-View	28.9 x 21.6 Deg
Instantaneous Field-of-View	0.062 mrad

FLIR

CCD Type	1/6”, 768 x 494 Pixels
Optical Zoom	1.00° - 22.5° Continuous optical zoom
Digital Zoom	0.5° - 0.37° Digital Zoom
Resolution	480 TV Lines

Electro-Optical

POP 300

Operational & Theater UA EO/IR Sensors

- EO – Requirement for a facial recognition capability while remaining undetected. (NIIRS 8+)
- IR – Requirement for identification and tracking while remaining undetected
- Laser Designator Range Finder – Requirement for integration with EO/IR sensor
- Operational and Theater UA
  - Global War on Terrorism requires precision and facial recognition capability
  - Stand-off range is important
- Goal for Industry
  - Multi-spectral Capability with Fusion Onboard
  - HDTV resolution (720P) in Full Color
  - Weapons quality precise coordinates

MQ-1 Predator / AGM-114 Hellfire

- Testing began in Feb 2001
- Operationally employed in Afghanistan and Iraq
- IOC declared 2005

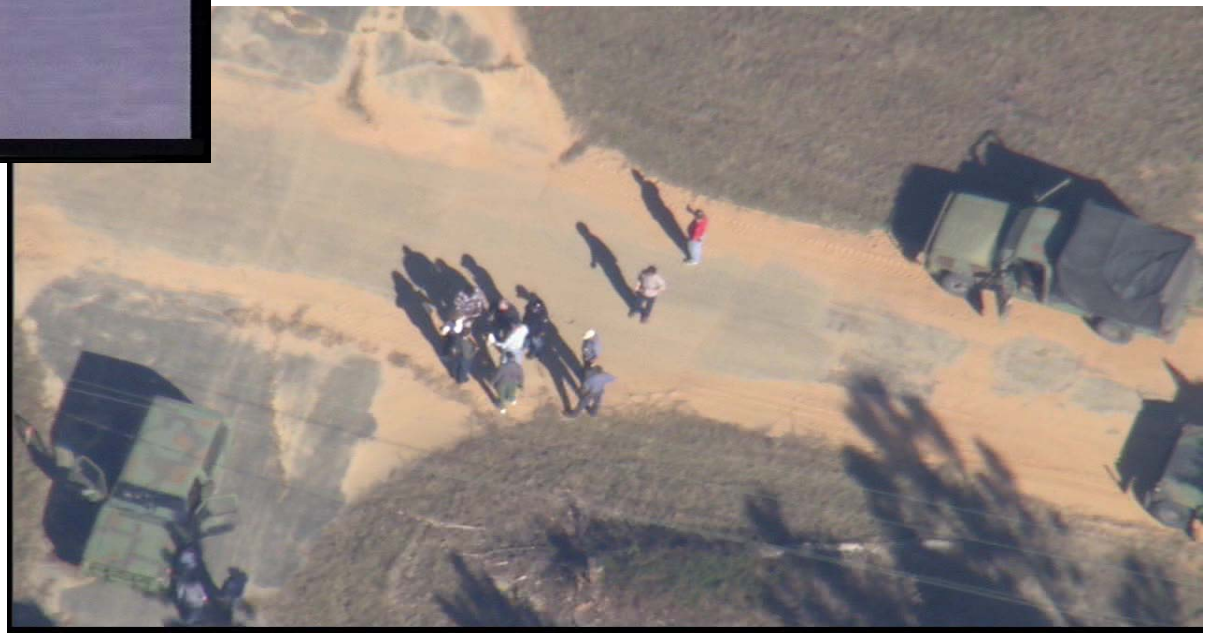
Predator / Hellfire Launch

Human Activity

Predator vs HDTV – 3 mile slant range

Predator, 955 mm focal length

HDTV, 1200 mm focal length



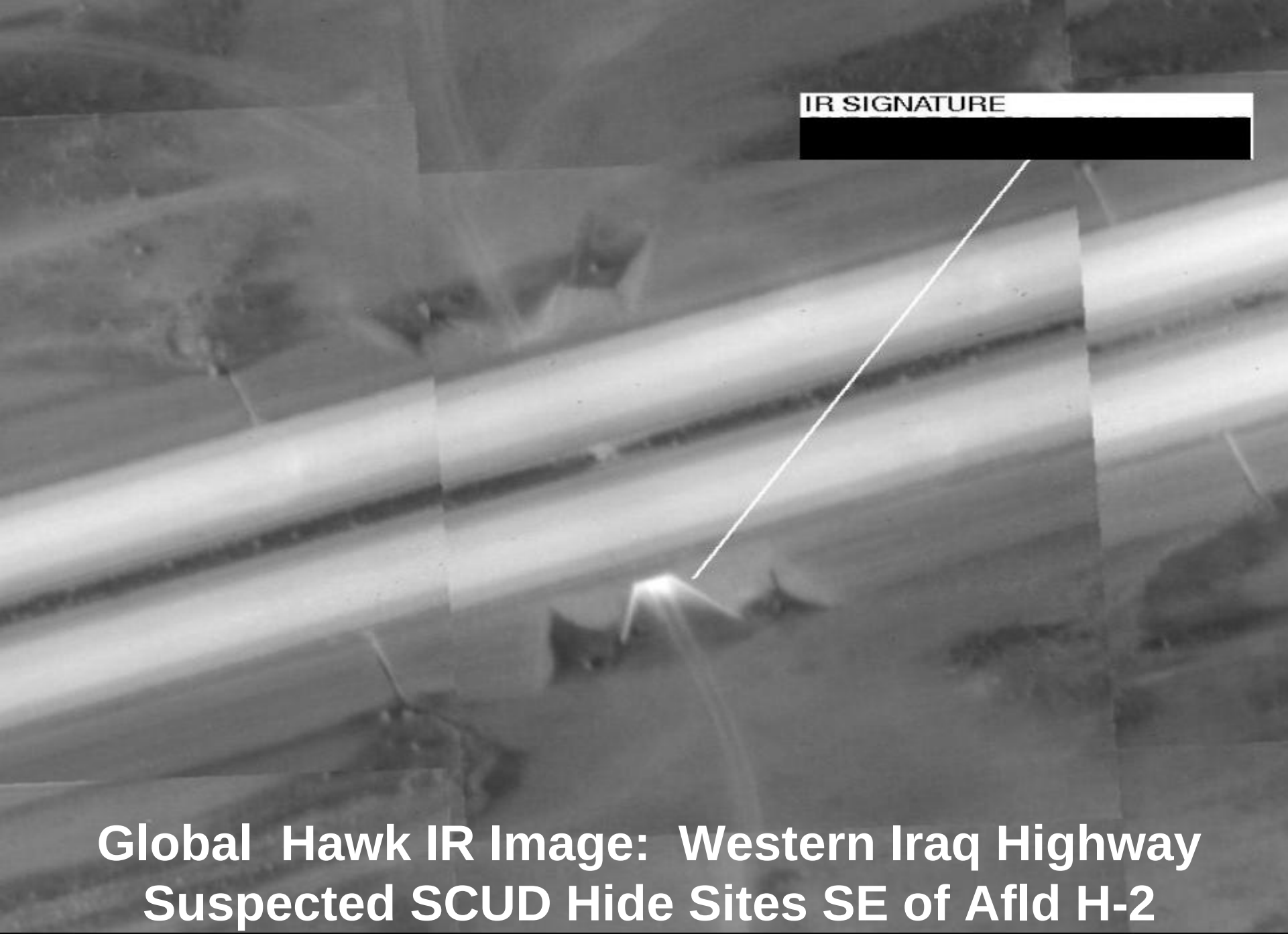
Global Hawk

High-altitude, long-endurance capability providing intelligence, surveillance and reconnaissance information

Unique Capabilities

- Persistence
- Responsive
- Multi-INT Collection

Global Hawk EO Image: Ad Hoc Suspected SA-2 Battery 20NM N of Baghdad



Global Hawk IR Image: Western Iraq Highway Suspected SCUD Hide Sites SE of Afld H-2

UA Radar Sensors

- Most UA will not have radar as the only system
- Goals for Industry
  - Literal radar image with same level of fidelity as low end monochromatic or high end IR image
  - Multi-band
    - Low frequencies for foliage penetration
    - High frequencies for detail
    - Sub-foot resolution
  - GMTI
  - Radar Video – Full motion video representation
  - Radar to EO/IR cueing

Army I-GNAT System

Characteristics / Description:

Wing Span	48.7 feet
Length	27 feet
Max Gross Weight	2,250 lbs
Fuel Weight	500 lbs
Speed Range	70-125 KIAS
Ceiling	25,000 feet
Endurance	40 hours
Payload (Internal)	450 lbs
Data Link	C-Band

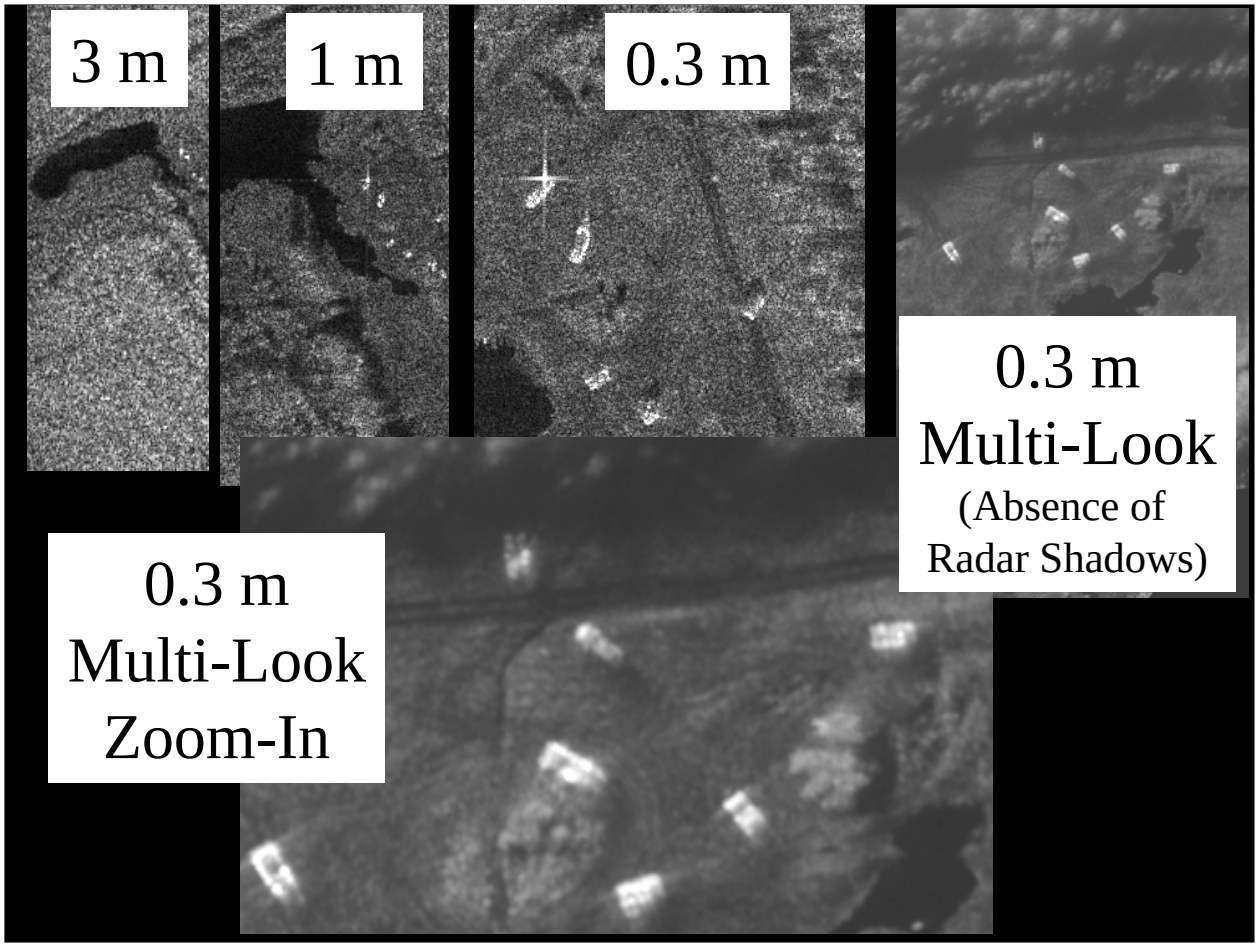
Army I-GNAT UAV Characteristics

- Multi-Payload / Mission Capable / Hellfire Capable
- Numerous combat area deployments
- C-130 Transportable
  - In-Place Logistics
- Current IRAD Programs:
  - TUAV GCS
  - Differential GPS Auto Launch & Recovery
  - Point-n-Click Operation (No sticks/pedals)

One System

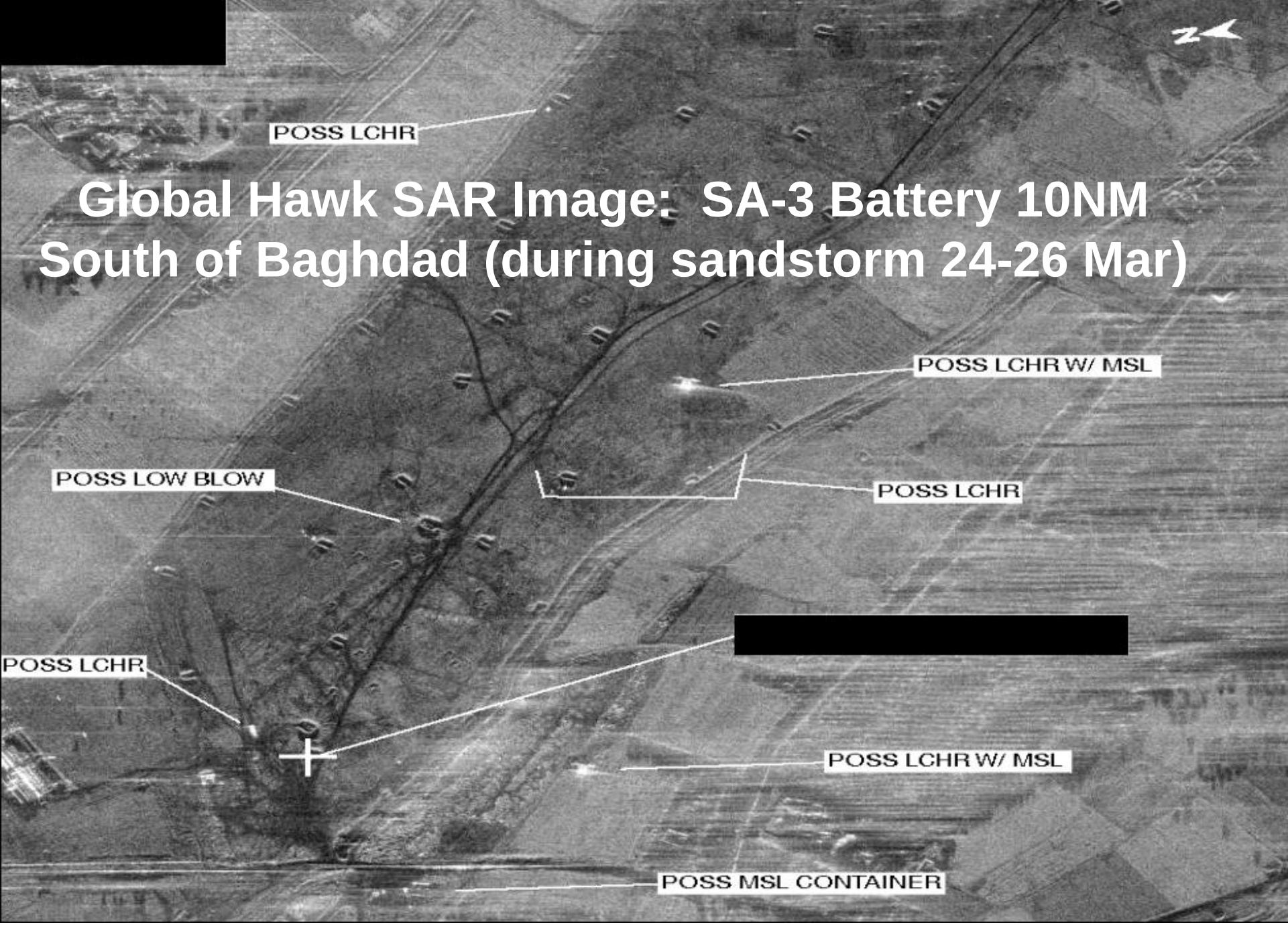
- Three (3) Air Vehicles
- One (1) Ground Control Station
- Two (2) Antennas
- Repair and Spare Parts
- Ground Support Equipment
- OIF since May 2004

LYNX SAR



Convoy Search Ft Dix: 2 x Cargo Trucks / 6 x Hummers

Global Hawk SAR Image: SA-3 Battery 10NM South of Baghdad (during sandstorm 24-26 Mar)



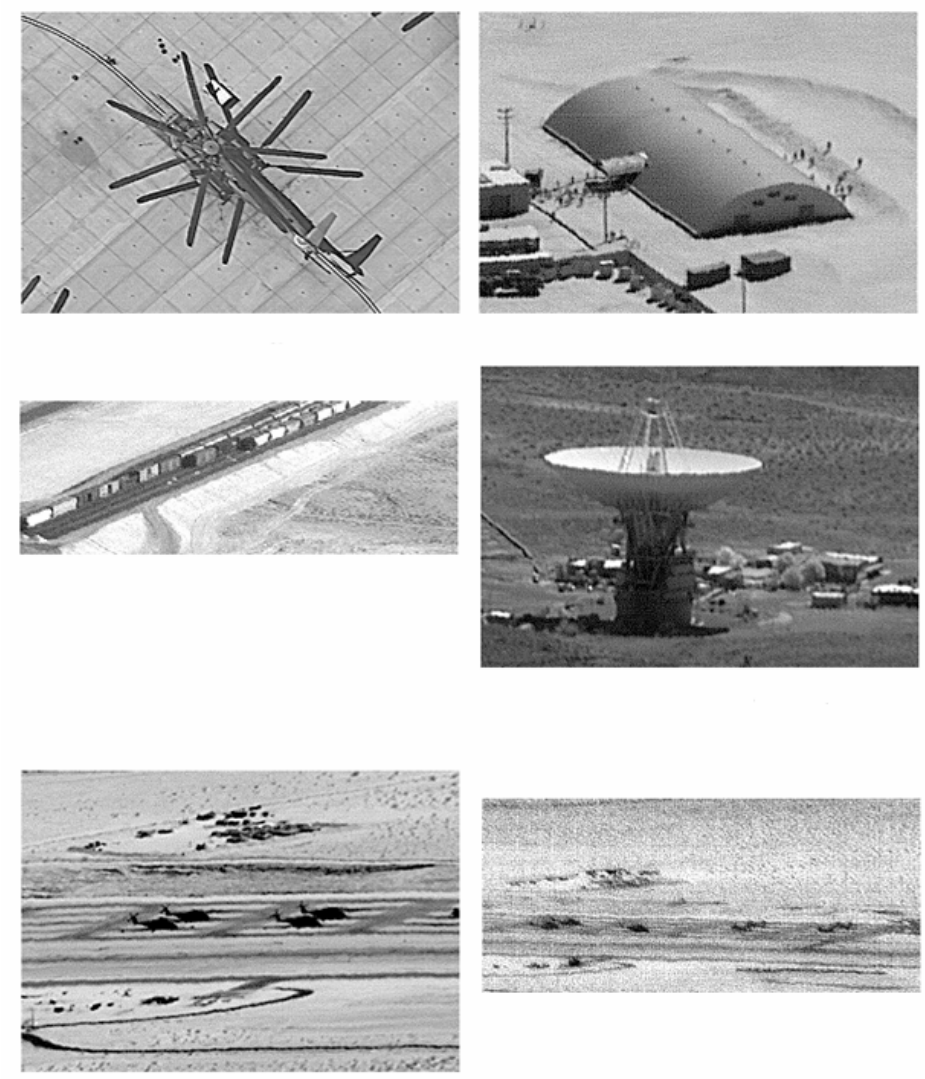
Sensor Standards

- Time sensitive operations currently hampered by
  - Lack of sensor metadata
  - Use of multiple, non-standard formats for sensor data
- Requirement for standard metadata for time sensitive operations
  - NGA Motion Video Metadata (KLV) allows derivation of Precision Guided Munitions-quality coordinates in near real-time from video
    - GRIDLOCK Advanced Concept Technology Demonstration
  - Critical component of Global Information Grid integration
    - Makes integration and fusion of products, and use by others, easier

Sensor Fusion

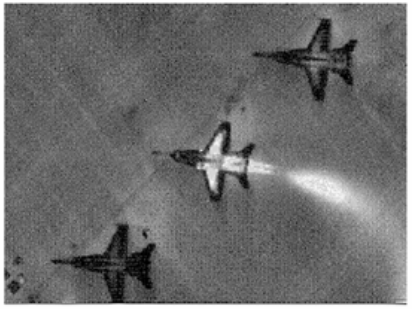
- Fusion enhances visible image
  - Hyperspectral has potential, but not robust
  - No single frequency provides best solution
  - Hyperspectral + EO/IR = Image with highlights
  - Need to be able to select the frequency, or combination thereof, that best fits the situation/environment

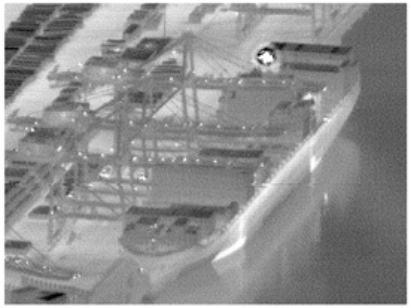
High Altitude ISR System Performance



Detail Image Chip examples from the *Pan/NIR band* at various ranges.

High Altitude ISR System Performance



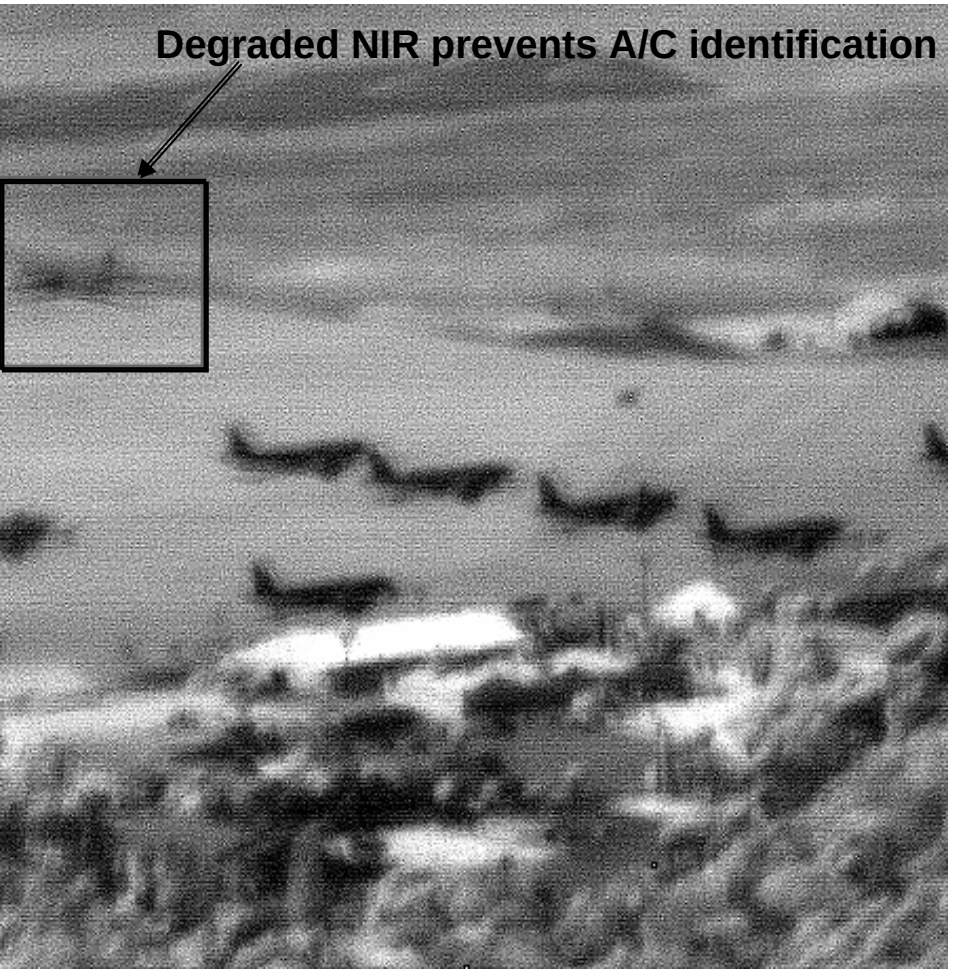


MWIR Band

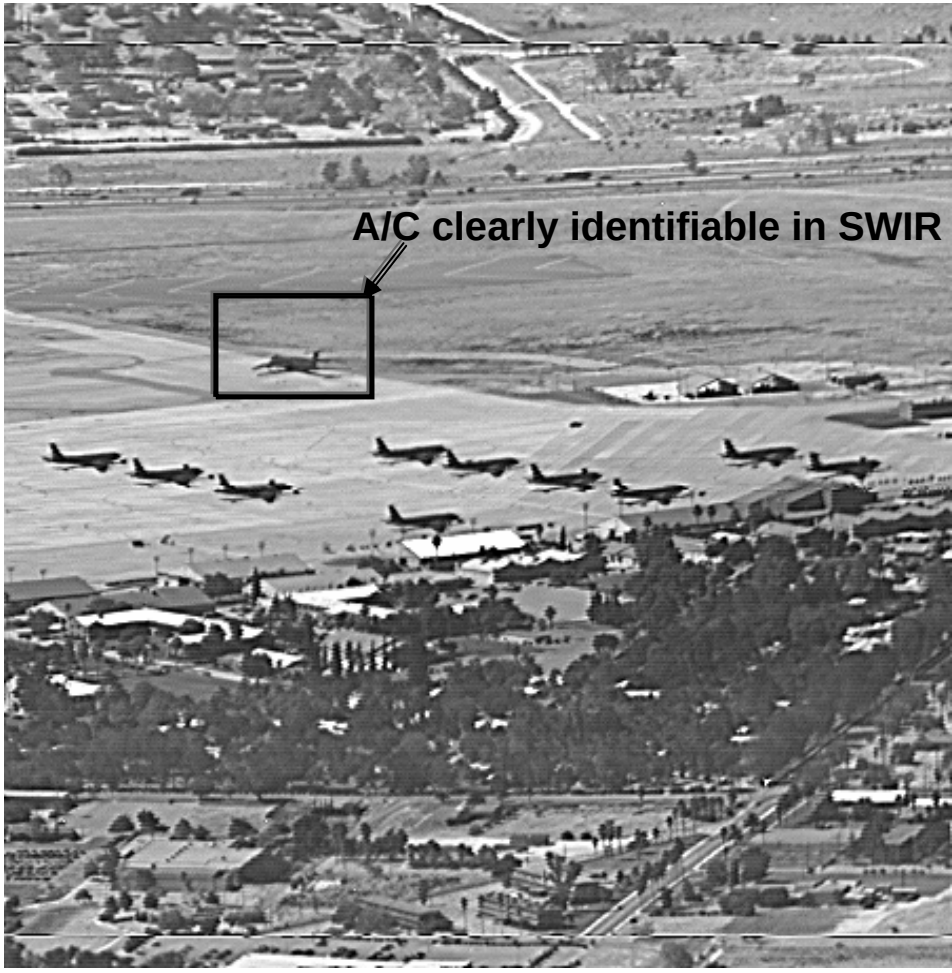
Night time Detail Imagery examples collected over various ranges.

Poor Visibility Enhancement (Pan vs. SWIR)

AOB: Identify/Detect Aircraft Activity



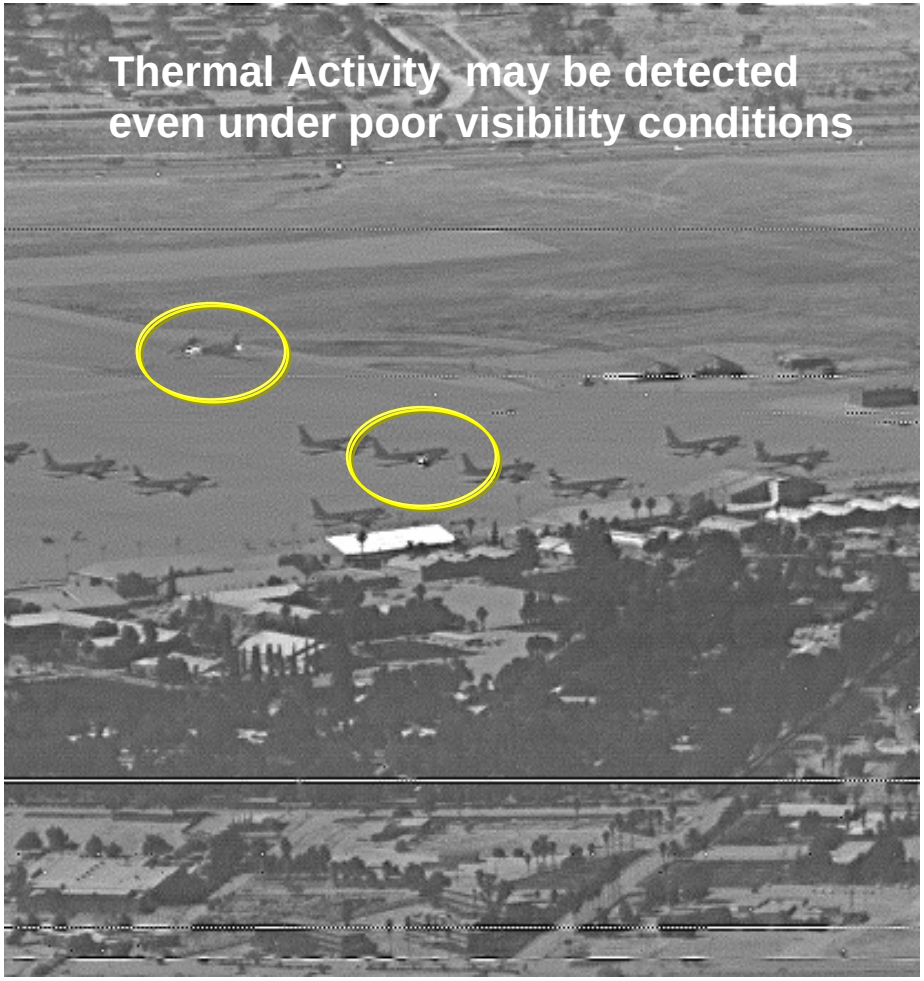
NIR



SWIR2

Poor Visibility Enhancement (SWIR & MWIR)

AOB Identify/Detect Aircraft Activity

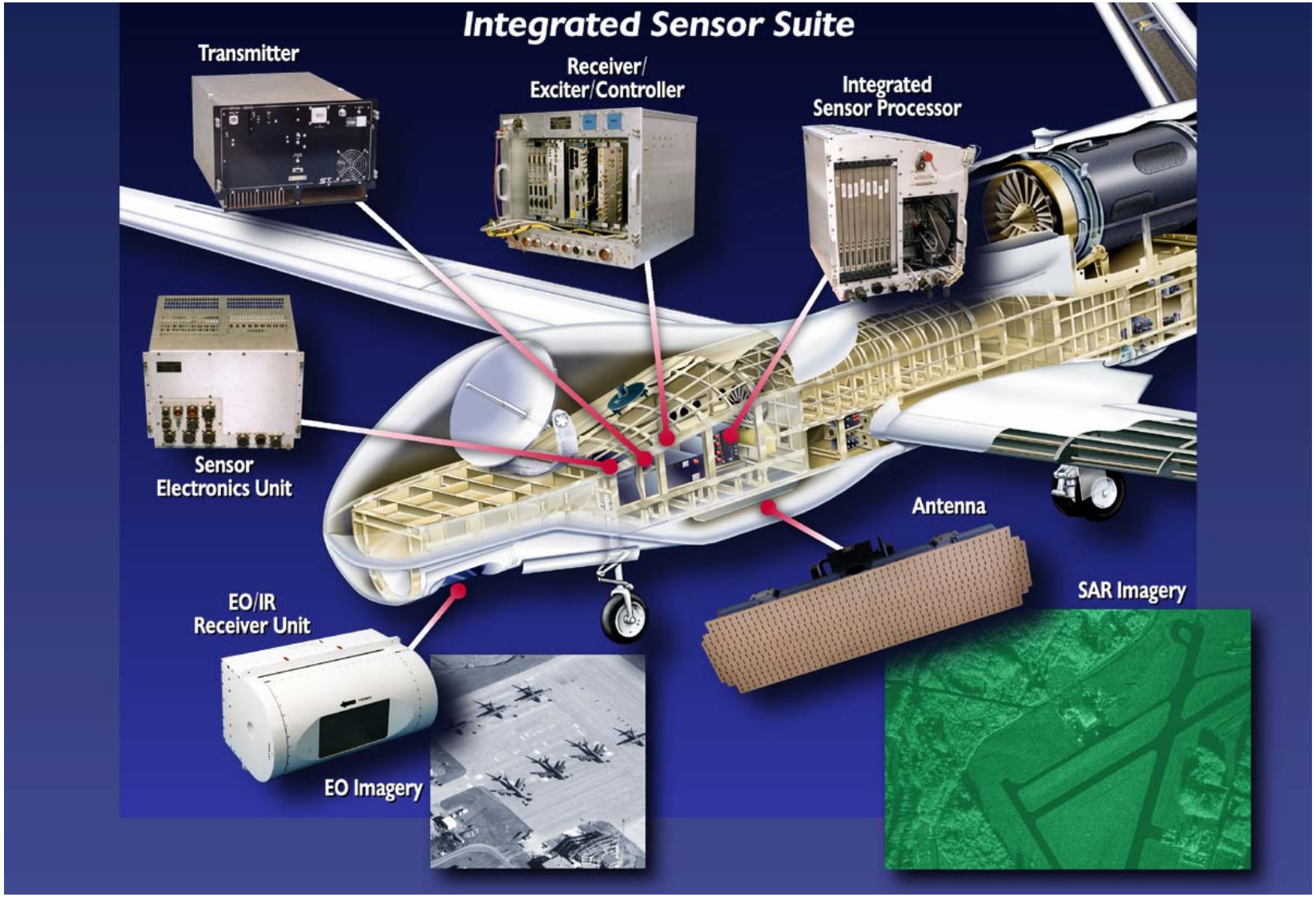


Summary

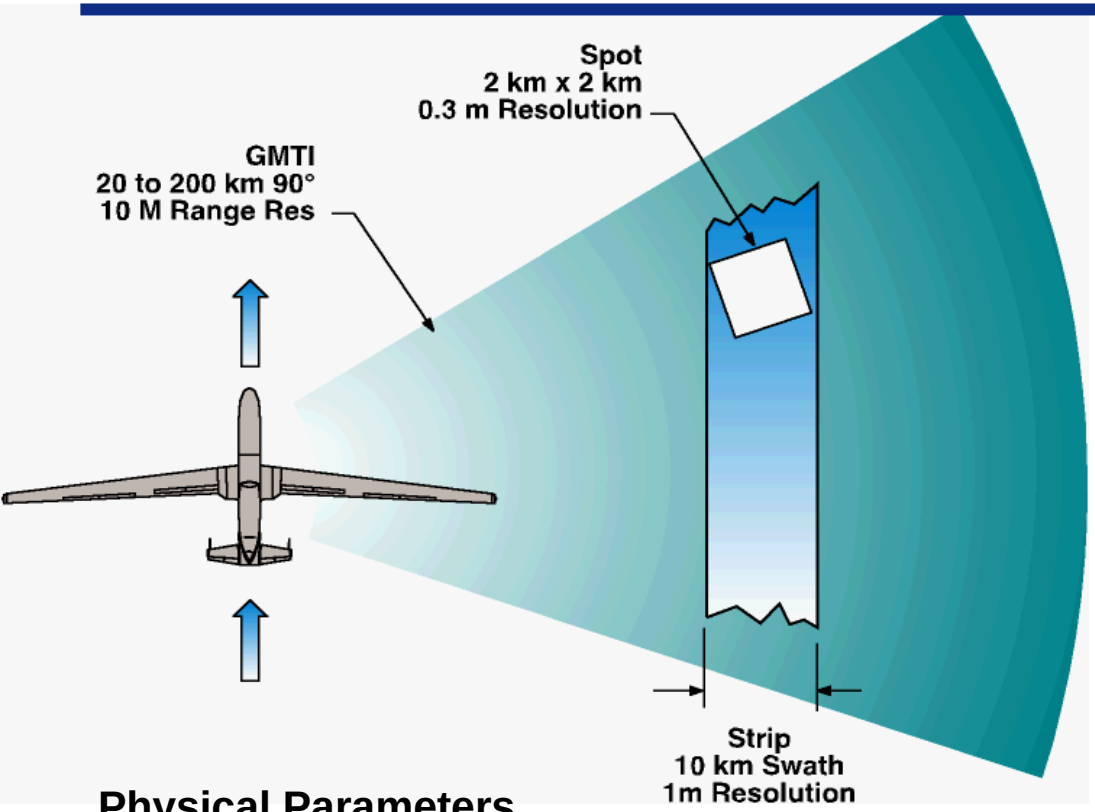
- Cost control is critical to development of UAS and UA sensors
- Standard metadata and standard data formats are:
  - Essential for time sensitive operations
  - Critical component of Global Information Grid integration
- Fusion enhances visual image
- Different sensor capabilities required to combat full range of asymmetrical threats:
  - Small
  - Tactical
  - Operational
  - Theater

Back Up Slides

Global Hawk
Integrated Sensor Suite



SAR/MTI Sensor



Radar Characteristics

X-Band Frequency
480 MHz Bandwidth
3.5 kW Peak Power
±45° Antenna Field of Regard
Either Side of Aircraft

Performance Parameters

Spot Mode:	**1900 images/day**
	200 km Range
	Squint to ±45°
Search Mode:	**138,000 sq km/day**
	200 km Range
GMTI Mode:	**15,000 sq. km/min Search Rate**
	4 knots Minimum Detectable Velocity @ 100 km

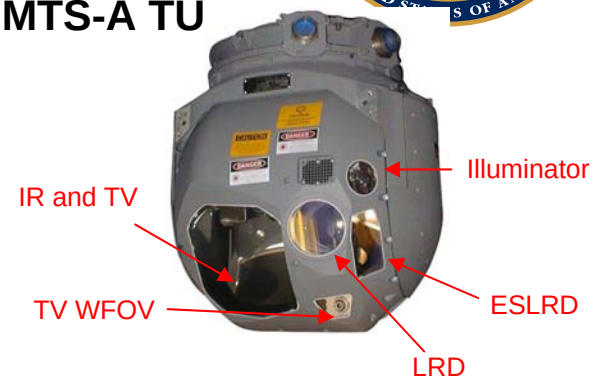
Physical Parameters

7 LRUs
15 cu. ft. (excluding antenna)
640 lb
Power Required: 4700 W 400 Hz 3ø
1300 W 28 Vdc

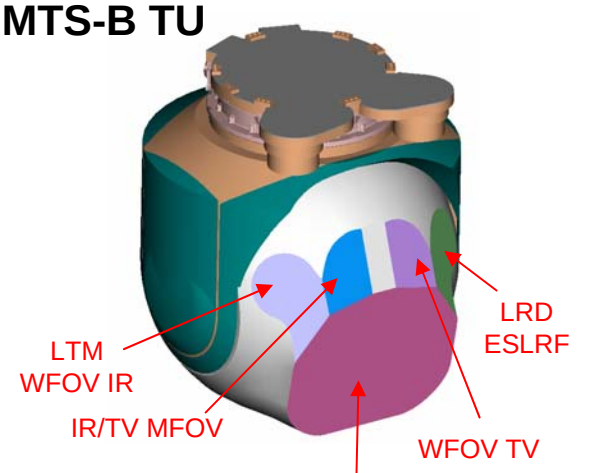
MTS System Overview

		MTS-A			MTS-B		
Physical Characteristics							
Diameter		17.43"			22.0"		
Height		18.70"			26.0"		
Weight							
Turret		124 lbs			230 lbs		
Electronics Box		30 lbs			30 lbs		
Power (nominal)		28Vdc, 30 Amps			28Vdc, 30 Amps		
Video Interfaces		RS-170, NTSC, Firewire, DVI			RS-170, NTSC, Firewire, DVI		
System Interface		MIL-STD-1553, RS-422, Ethernet			MIL-STD-1553, RS-422, Ethernet		
Temp		-54C to +55C			-54C to +55C		
Altitude		30,000 ASL			50,000 ASL		
Imaging Sensor							
Fields of View (FOV)		TV	IR	IITV	TV	IR	IITV
Wide	W-1 45°	33 X 44	33 X 44	--	34 X 45	34 X 45	--
Medium-Wide	W-2 22°	15X 20	15X 20	--	17 X 22	17 X 22	--
Medium	M-1 7.6°	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6
	M-2 2.6°	--	--	--	2.2 X 2.6	--	--
Narrow	M-2 3.7°	1.2 X 1.6	1.2 X 1.6	1.2 X 1.6	--	2.8 X 3.7	2.8 X 3.7
	M-3 1.3°	--	--	--	0.96 X 1.3	--	--
Ultra-Narrow	N-1 0.63°	0.21 X 0.28	0.6 X 0.8	0.6 X 0.8	0.47 X 0.63	0.47 X 0.63	0.47 X 0.63
	N-2 0.22°	--	--	--	0.16 X 0.22	--	--
	N-2 0.31°	--	--	--	--	0.23 X 0.31	0.23 X 0.31
	N-3 0.011°	--	--	--	0.08 X 0.11	--	--
Spectral Band (microns)		0.4 to 0.7	3 to 5	0.6 to 0.89	0.4 to 0.7	3 to 5	0.6 to 0.89
Focal Plane Array Size		640 X 480 InSb			640 X 480 InSb		
Autotracker		Yes			Yes		
Laser Rangefinder Designator		Yes			Yes		
Eyesafe Laser Rangefinder		Not Installed			Yes		
Laser Illuminator		Yes			Yes		
Laser Spot Detection		Yes			Yes		
Inertial Measurement Unit		Yes			Yes		
Target Location Error		Weapons Quality			Weapons Quality		

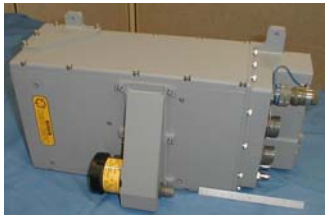
MTS-A TU



MTS-B TU



Common EU



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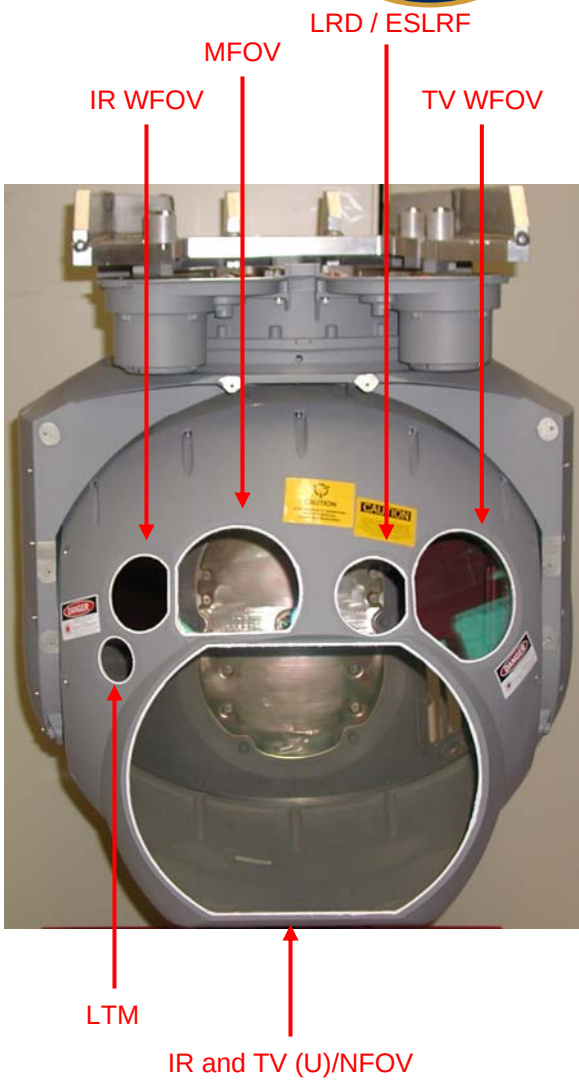
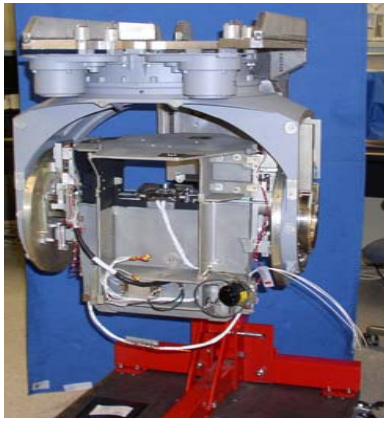
MTS-B Prototype

		MTS-A			MTS-B		
Physical Characteristics							
Diameter		17.43"			22.0"		
Height		18.70"			26.0"		
Weight							
Turret		124 lbs			230 lbs		
Electronics Box		30 lbs			30 lbs		
Power (nominal)		28Vdc, 30 Amps			28Vdc, 30 Amps		
Video Interfaces		RS-170, NTSC, Firewire, DVI			RS-170, NTSC, Firewire, DVI		
System Interface		MIL-STD-1553, RS-422, Ethernet			MIL-STD-1553, RS-422, Ethernet		
Temp		-54C to +55C			-54C to +55C		
Altitude		30,000 ASL			50,000 ASL		
Imaging Sensor							
Fields of View (FOV)		TV	IR	IITV	TV	IR	IITV
Wide	W-1 45°	33 X 44	33 X 44	--	34 X 45	34 X 45	--
Medium-Wide	W-2 22°	15X 20	15X 20	--	17 X 22	17 X 22	--
Medium	M-1 7.6°	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6	5.7 X 7.6
	M-2 2.6°	--	--	--	2.2 X 2.6	--	--
Narrow	M-2 3.7°	1.2 X 1.6	1.2 X 1.6	1.2 X 1.6	--	2.8 X 3.7	2.8 X 3.7
	M-3 1.3°	--	--	--	0.96 X 1.3	--	--
Ultra-Narrow	N-1 0.63°	0.21 X 0.28	0.6 X 0.8	0.6 X 0.8	0.47 X 0.63	0.47 X 0.63	0.47 X 0.63
	N-2 0.22°	--	--	--	0.16 X 0.22	--	--
	N-2 0.31°	--	--	--	--	0.23 X 0.31	0.23 X 0.31
	N-3 0.011°	--	--	--	0.08 X 0.11	--	--
Spectral Band (microns)		0.4 to 0.7	3 to 5	0.6 to 0.89	0.4 to 0.7	3 to 5	0.6 to 0.89
Focal Plane Array Size		640 X 480 InSb			640 X 480 InSb		
Autotracker		Yes			Yes		
Laser Rangefinder Designator		Yes			Yes		
Eyesafe Laser Rangefinder		Not Installed			Yes		
Laser Illuminator		Yes			Yes		
Laser Spot Detection		Yes			Yes		
Inertial Measurement Unit		Yes			Yes		
Target Location Error		Weapons Quality			Weapons Quality		

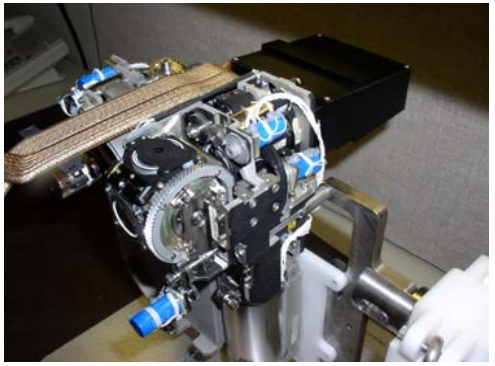


MTS-B Hardware

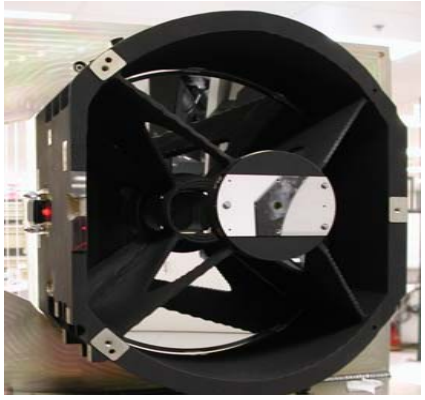


MTS-B Gimbal

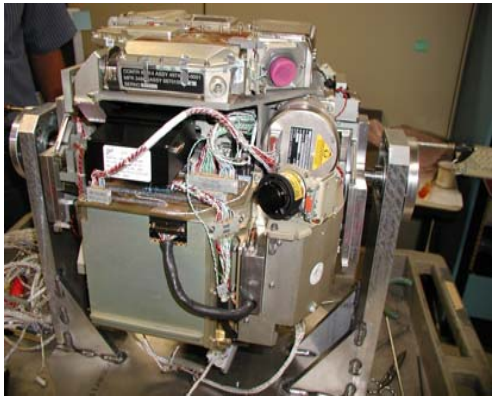
MTS-B Turret Unit



Common Imager



MTS-B 12X Afocal



MTS-B Receiver Assy

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